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ESTIMATES OF THE MINIMUM ANNUAL CIVILIAN PETROLEUM CONSUMPTION OF THE SOVIET BLOC IN THE EVENT OF A GENERAL WAR IN FISCAL YEAR 1954

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W A R N I N G

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Summary

Estimates of civil consumption of petroleum products in the Soviet Bloc during wartime fiscal year 1954 are presented in Table I. For comparison, estimated civil consumption of petroleum products during peacetime fiscal year 1953, the immediately preceeding peacetime period, is also presented.

Table I

Estimated Civil Consumption of Petroleum Products in the Soviet Bloc, Peacetime Fiscal Year 1953 Compared with Wartime Fiscal Year 1954

Million Metric Tons

Major Product Group	Peacetime Fiscal Year 1953	Wartime Fiscal Year 1954 Range of Estimate Upper Limit	Range of Estimate Lower Limit	Best Estimate	Percent Decrease Best Estimate Fiscal 1954 from Fiscal 1953
Aviation Gasoline	.6	.1	.1	.1	83.3
Other Distillate Fuels	24.3	20.8	13.5	18.5	23.9
Residual Fuels	14.9	13.2	8.7	13.2	11.4
Lubricants	3.4	3.3	1.9	2.8	17.6
Total	43.2	37.4	24.2	34.6	19.9

The wartime estimates shown in Table 1 are based on the assumption that a general war begins on 1 July 1953. The best estimate presents the most probable wartime civilian consumption consistent with the degree of economic activity necessary to support a prolonged general war, assuming no attrition. The range of estimates presents as an upper limit a possible level of wartime consumption consistent with moderate wartime rationing, and assumes no attrition. It is considered

probable, however, that wartime rationing will be more severe than this case would indicate. The lower limit of the range of estimates presents a level of wartime civil consumption consistent with the required assumption that the Soviet Bloc could support a general war on the basis of 45 percent of its 1952 industrial capacity. 1/ This lower estimate implies considerable economic dislocation, and implies problems in crude oil production and petroleum refining which could only be solved by wasteful and arbitrary measures.

The wartime estimates presented reflect a low degree of conversion of petroleum consuming equipment to other fuels. An analysis has been made of the possibilities of securing extensive conversions in wartime in the Soviet Bloc. Particular attention has been devoted to determining the possibilities of obtaining conversions which would result in savings of automotive fuels. In general, the logic of conversion is that of substituting incremental inputs of steel, manpower, plant time, and solid fuels in order to secure lower inputs of liquid fuels into the wartime economy. On the basis of the data collected, it seems improbable that the Soviet Bloc would be able to find the necessary incremental inputs in wartime to secure significant savings of liquid fuels. This would be particularly true in the first year of the war. It should also be particularly true if the Soviet industrial plant were operating at only 45 percent of 1952 capacity.

The analysis which follows provides detailed breakdowns of civil consumption of petroleum products in the Soviet Bloc, by major geographic areas, by product groupings, and by consumer groups, where these breakdowns are available. In the case of the

Asiatic Satellites it has not been possible to separate civil and military requirements. As a result, all of the estimates presented herein reflect the estimated consumption of petroleum products by the Asiatic Satellites for both military and civil purposes.

1. USSR.

The estimated civil consumption of petroleum products in the USSR in fiscal year 1953 is given in Table 2.* These estimates, with the exception of those concerning agricultural consumption of petroleum products, have been taken from CIA/RR PR 17 I-F, Civil Consumption of Petroleum Products in the USSR. 2/ The estimates of agricultural consumption are based upon later CIA calculations.

Estimates are also presented in Table 2 of the most probable minimum civil consumption of petroleum products in the USSR during fiscal year 1954, assuming a general war beginning in July 1953, and assuming no attrition.

Table 2 presents estimates of the upper and lower limits of the possible range of civil consumption of petroleum products in the USSR during fiscal year 1954, in the event of a general war beginning in July 1953.

A summary of the analysis on which these estimates are based follows. The consumer categories used herein are those defined in PR 17, I-F, cited above.

a. Motor Transport.

In estimating the wartime consumption of liquid fuels by civil motor transport, several factors exist which affect the estimates of the wartime out which it may be possible to make from the preceeding peacetime level of consumption in the USSR.

(1) It has been assumed that no new vehicles will be added to the civil motor park in wartime.

(2) It is considered probable that civil motor vehicles may be transferred to the military in wartime. An estimate of the number of vehicles which might be

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* Table 2 follows on page 5.

Table 2

Estimated Civil Consumption of Petroleum Products in the USSR
Peacetime Fiscal Year 1953 and Best Estimate Wartime Fiscal Year 1954

Million Metric Tons

	Motor Transport	Agriculture	Shipping	Railroads	Industry	Household	Air Transport	Total	Percent Decrease From Fiscal Year 1953
Fiscal Year 1953 - Peacetime									
Aviation Gasoline	0	0	0	0	0	0	.5	.5	
Other Distillate Fuels	8.4	8.6	.6	.1	2.1	1.9	0	21.7	
Residuals	0	0	1.2	1.8	10.7	0	0	13.7	
Lubricants	.4	1.0	.1	.1	1.5	0	Negligible	3.1	
Total	8.8	9.6	1.9	2.0	14.3	1.9	.5	39.0	
Fiscal Year 1954 - Wartime (Best Estimate)									
Aviation Gasoline	0	0	0	0	0	0	Negligible	Negligible	100.0
Other Distillate Fuels	6.1	6.8	.6	.1	1.6	1.0	0	16.2	25.3
Residuals	0	0	1.2	1.8	9.0	0	0	12.0	12.4
Lubricants	.3	.7	.1	.1	1.3	0	Negligible	2.5	19.3
Total	6.4	7.5	1.9	2.0	11.9	1.0	Negligible	30.7	21.3
Fiscal Year 1954 - Wartime (Possible Upper Limit)									
Aviation Gasoline	0	0	0	0	0	0	Negligible	Negligible	100.0
Other Distillate Fuels	6.1	8.6	.6	.1	2.1	1.0	0	18.5	14.7
Residuals	0	0	1.2	1.8	9.0	0	0	12.0	12.4
Lubricants	.3	1.0	.1	.1	1.5	0	Negligible	3.0	3.3
Total	6.4	9.6	1.9	2.0	12.6	1.0	Negligible	33.5	14.1
Fiscal Year 1954 - Wartime (Possible Lower Limit)									
Aviation Gasoline	0	0	0	0	0	0	Negligible	Negligible	100.0
Other Distillate Fuels	4.0	5.0	.5	.1	1.1	.5	0	11.2	48.4
Residuals	0	0	1.1	1.8	4.6	0	0	7.5	45.3
Lubricants	.1	.5	.1	.1	.8	0	Negligible	1.6	48.4
Total	4.1	5.5	1.7	2.0	6.5	.5	Negligible	20.3	47.9

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transferred, however, is not considered feasible, and these potential transfers have been ignored in this report.

(3) It is considered possible that some civilian motor vehicles may be converted to gas generators, and compressed gaseous fuels. In view of the analysis which is presented in Appendices A and B of this report, it has been estimated that the total effect of the conversions which might be anticipated in the first year of a war beginning in 1953 would be to release liquid fuels in the amount of 0.25 to 0.5 million metric tons per year.

(4) It is considered that the use of the remaining civilian motor vehicles would be curtailed, and that any use of motor transport for pleasure purposes will be eliminated. Requirements for motor transport for construction activity should decrease proportionately to the wartime decrease in construction. Consolidation of motor transport requirements is considered possible to some extent.

These factors suggest that substantial cuts might be made in wartime motor transport consumption of liquid fuels. However, motor transport requirements for essential production of military and civilian end-items, and essential requirements of motor transport for agriculture, must be met, particularly in wartime. Soviet civil motor transport is presently operating under conditions of severe rationing, which suggests a low degree of flexibility in this requirement.

The degree to which liquid fuel allocations to civil motor transport in the USSR can be cut in wartime will depend on the interaction of these and other factors. Personnel from Petroleum Administration for Defense (PAD) familiar with aspects of petroleum rationing in the US and Western Europe, believe a cut of 25 percent from

the previous peacetime levels of ~~levels of~~ consumption might be realistic under these conditions. In speculating about the most extreme cut which the Soviet war potential might survive, a figure of 50 percent has been arbitrarily chosen. This figure is in line with the level of industrial activity stated in the terms of reference of this report, and with the short term level of agricultural activity which has been indicated in the following section.

Lubricant requirements have been calculated to be about 5 percent of fuel requirements. Since it is possible that some reprocessing of lubricants might be anticipated in wartime, a lower limit of 3 percent of fuel requirements has been set as the minimum requirement for lubricants for civil motor transport.

b. Agriculture.

During World War II work done (in terms of soft plowing) by Machine Tractor Stations (MTS) in the USSR fell from 225 million hectares in 1940 to 95.8 million hectares in 1944, and to 115.5 million hectares in 1945. 3/ This represents a decrease of about 57 percent between 1940 and 1944, and of 49 percent between 1940 and 1945. The 1945 figure is perhaps the more useful, since the Ukraine was in Soviet hands during that year. Data for the same period indicate that the agricultural tractor park of the USSR in terms of physical units, decreased 30.6 percent between 1940 and 1945. 4/ In terms of horsepower, it is estimated that the agricultural tractor park decreased 29.1 percent between 1940 and 1945. 5/ As a further indicator, it is known that Soviet hectarage of spring wheat, ~~which is~~ planted in areas which were under Soviet control during the whole of World War II, was reduced to 2.5 million hectares in 1946, as compared to 5.1 million hectares in 1938, a reduction of about 50 percent. 6/

The above data suggest that the Soviet economy during World War II was able to subsist on greatly reduced agricultural production. Correspondingly, the number of tractors, and the tractor horsepower, employed were also greatly less than prewar. Data for war years before 1945 are distorted, however, by the fact that parts of the Soviet Union were either occupied or actually in the battle zone. Moreover, the production of Soviet agriculture in this period was supplemented by substantial imports of food and clothing, which indicates that indigenous agricultural activity may have been below the subsistence level.

With this historical background, it is possible to speculate on probable level of agricultural consumption of liquid fuels in the event of a future war. It must be assumed, throughout, that the Soviets will probably attempt to operate their agricultural machinery at peacetime levels for as long a period as possible, in order to maintain a solid agricultural underpinning to the wartime economy. The estimates which are presented represent current thinking about the minimum levels of agricultural activity which would support the war economy.

The following factors affect these estimates:

(1) It is considered probable that tractors will be transferred from agriculture to the military. It has not been possible to estimate how many transfers could be expected, but it is probable that the heavier diesel tractors would be favored by the military.

(2) It is considered improbable, in view of the analysis presented in Appendix A, that an appreciable number of tractors would be converted to gas generators in the initial phases of the war. In addition to the data presented in

Appendix A, it may be stated that conversion of tractors to gas generators is even more difficult than the conversion of trucks, since there is no space on the chassis of most liquid fuel tractors to install the bulky gas generator units. Notwithstanding the latitude of gas generators with regard to fuels, difficulties might be encountered in providing solid fuels for gas generator tractors in agricultural areas. The Soviet experiments with agricultural wastes as generator fuel have been unsatisfactory, and the problems of transporting solid fuels in bulk, especially in wartime, might be even more serious than those encountered in supplying liquid fuels.

(3) Compressed gas tractors and electric tractors are not believed to be present in consequential numbers in the USSR at the present, and it is not believed that their numbers would materially increase in wartime.

(4) It is again assumed that no additions would be made to the agricultural park in wartime.

On the basis of these and other considerations, it is estimated that the USSR would not be seriously hampered in its effort under a condition of loss of 30 percent of the horsepower of the peacetime agricultural tractor park. As a lower limit, it is believed that the USSR might survive for a limited period a 50 percent cut in the horsepower of the agricultural tractor park.

In terms of the fuels which would be conserved, it has been estimated that the tractors which would be withdrawn in the most probable case would be diesels, notably the S-80 and DT-54 models. In the more extreme case, a reduction has also been made in the number of kerosene tractors operating. In the extreme case, a further reduction of fuel requirements has been made, representing a reduction of 25 percent in the use of combines.

c. Shipping.

No reduction is anticipated in the consumption of liquid fuels in wartime by Soviet high seas, Caspian, or inland water shipping. The wartime demands placed on the transportation net of the USSR are expected to be at least as high as in peacetime. Therefore, the fuel consumption of these fleets is expected to continue at peacetime levels. Technological difficulties make it very improbable that either the diesel or fuel oil consuming units of the high seas or Caspian fleets would be converted to other fuels within the first year of the war. In the case of the inland waterways, it is possible that some of the diesel units in this fleet could be converted to gas generators, since it is known that the Soviets have been experimenting with this conversion. It is also possible that some of the fuel oil burners of the inland fleet could be converted to solid fuels, since the smaller size of these engines might make conversion more easy to manage. The extreme case, therefore, shows a small reduction in the fuel requirements of Soviet shipping.

d. Railroads.

It is not anticipated that any reduction can be made in the fuel consumption of the railroads, since wartime rail traffic should at least equal peacetime traffic. Soviet experiments with gas-generator locomotives, and gas-fueled locomotives have not reached the point where these should materially affect the rail fuel situation in wartime. It is not considered that there would be any strong incentive to convert the fuel oil burning locomotives to other fuels, since their appears to be no reason to believe that fuel oil will be in short supply during a war.

e. Industry.

The major part of the industrial consumption of petroleum products in the USSR is of residual fuel oil. In calculating the consumption of residual fuel oil by Soviet industry in wartime, the same assumption has been made in this report as was the case in PR-17, (I-F) namely: that all residual fuel oil which is produced by the USSR petroleum refining industry, and which is not consumed by the Navy, the railroads, or shipping, will be available as an industrial fuel. As long as Soviet crude production continues at peacetime levels, there is every reason to believe that no very substantial cuts will be made in the allocations of residual fuel oil to industry. There is no military requirement for this product which can be expected to increase in wartime, other than a modest increase in the requirements for naval bunkers. The estimate presented in the most probable case is based on this assumption.

However, if it is assumed that the Soviet economy could operate at 45 percent of its 1952 capacity, as stated in the terms of reference, it is apparent that the residual fuel requirement for this degree of activity would be substantially less than 9 million metric tons. It is estimated that residual fuel requirements under these conditions might be in the order of 50 percent of estimated 1952 peacetime consumption, or about 4.6 million metric tons. It should be noted that the presentation of this figure implies either a reduction in crude oil production to levels well below peacetime fiscal year 1953, or the dumping of residual fuel oil.

A preliminary investigation has been made of the possibilities of converting substantial portions of the Soviet fuel oil consuming industrial plants to other

fuels. Not enough is presently known about the nature of these plants to know whether a number of them are capable of operating on other fuels without extensive redesign. Under these circumstances, it has been assumed that most of the industrial fuel oil burning equipment is of the simplest type, and designed to burn fuel oil exclusively. In consultation with personnel of the Coal Branch of the Bureau of Mines, it was agreed that the conversion of industrial fuel oil burners of the permanent type requires very considerable investments of steel, manpower, and time. It is their opinion that in the US it would be difficult to convert any large number of such installations to solid fuels in any future war because of these large input requirements. In fact, they feel that it might not even be possible to convert as many installations as was the case in World War II. During World War II, only 11 percent of the fuel oil burning installations in the US were converted to solid fuel at the height of the effort to secure these conversions. 7/

In view of the experience of the US with conversion, and the fact that it is believed that conversion would present insuperable difficulties to the US in any future war, it has been assumed that the less highly industrialized and less flexible economy of the USSR would not find it possible to support extensive conversions. This would be particularly true if overall industrial activity in the USSR were operating at 45 percent of its 1952 capacity.

Very little is known about industrial requirements for distillate fuels. In view of this fact, an arbitrary reduction of 25 percent has been made in these requirements as the most probable case. This cut reflects the reduction in fuel requirements for industrial construction, together with more severe rationing of distillate products to industrial installations in wartime. As an extreme case, a 50 percent cut has been indicated as being possible.

In the matter of industrial lubricants, it is believed that approximately the same quantity of lubricants would be required as in peacetime. Reprocessing of industrial lubricants may reduce this figure somewhat. In the extreme case, a reduction of 50 percent has been made in the lubricant requirements estimated for 1952.

f. Household.

Included in the estimates of the household consumption of petroleum products in fiscal year 1953 is the estimated consumption of kerosene by industrial installations, since it has been impossible to separate these requirements in Soviet sources. The size of the Soviet industrial requirement is not known. The combined industrial and household consumption of kerosene in wartime has been cut 50 percent from peacetime levels. This cut is assumed to fall largely on households, since heavy cuts could be made in the civilian allocation of kerosene without affecting the ability of the Soviet economy to wage war. As a maximum cut, a 75 percent decrease from peacetime levels is indicated. This figure would take into account industrial activity at a level of 45 percent of peacetime 1952.

g. Air Transport.

It has been assumed that virtually all of the civil air fleet of the USSR would be turned over to the military in the event of war.

2. European Satellites.

It is estimated that the European Satellites will require, as an absolute minimum, about 3 million metric tons of petroleum products in wartime fiscal year 1954. Since the civil consumption of petroleum products in this area is stringently restricted, it is not believed that the civil economics could sustain more than a 10 percent cut compared with peacetime fiscal year 1953. Table 3 indicates the estimated civil consumption in fiscal year 1953 and fiscal year 1954 of the major product groups. 3/

Table 3

Estimated Civil Consumption of POL in the European Satellites

Major Product Group	Peacetime Fiscal Year 1953	Wartime Fiscal Year 1954	Percent Decrease Fiscal Year 1954 from Fiscal Year 1953
Aviation Gasoline	25	0	100
Other Distillate Fuels	2,185	1,900	13
Residuals	855	855	0
Lubricants	245	230	6
Total	3,310	2,985	10

It has been assumed that in wartime all civil aviation will be taken over by the military. Since the military demand for residuals is negligible, and since there will always be residuals produced which will be available for consumption, it is believed there will be no cut in this category. In addition in some areas, such as Rumania, there is a scarcity of other suitable fuels for industry, rail transport and water transport. Again, the technical and economic difficulties in conversion from residual fuel oil make it unlikely that consumption could be reduced. Over

85 percent of the over-all cut in consumption will be in the distillates, principally gasoline and diesel oil, the petroleum products most needed by the military. It is felt that as a result of the reductions outlined above there could be a small savings of about 6 percent in lubricants.

The estimated consumption of petroleum products by the major consuming groups is shown in Table 4. 8/

Table 4

Estimated Civilian Consumption of POL by Major Consumers

Thousand Metric Tons

Major Consumer	Peacetime Fiscal Year 1953	Wartime Fiscal Year 1954	Percent Decrease Fiscal Year 1954 from Fiscal Year 1953
Motor Transport	1,060	900	15
Industry	925	850	8
Agriculture	625	600	4
Household	240	200	17
Rail Transport	235	235	0
Water Transport	200	200	0
Air Transport	25	0	100
Total	3,310	2,985	10

Although virtually all of the transport in the European Satellites is believed to be essential commercial transport that probably can not be cut appreciably, it is felt that some savings in gasoline and diesel oil can be effected. Civil aviation is expected to be eliminated and private motor transport even more severely controlled than at the present time. Some of the trucks, particularly the diesels, may be turned over to the military. However, it is doubted that either rail or water transport can be cut at all.

Although the largest part of industrial consumption is in the form of residual fuel oil, some gasoline and diesel oil is used, with gasoline making up the majority of the distillates. This gasoline is probably used in construction work and for

motor transport within industrial complexes. It has been assumed that these activities will be curtailed resulting in a reduction of about 75,000 metric tons in industrial consumption.

Household consumption is in the form of kerosene for lighting and cooking. Fuel wood is expected to be used as a substitute for kerosene in cooking, thereby decreasing domestic use of petroleum products by some 40,000 tons, or 17 percent. Since kerosene is already severely rationed for domestic pruposes, it is extremely doubtful that a deeper cut could be effectively accomplished.

Although agriculture in the European Satellites is not mechanized to a large degree, more and more mechanical draft power is being utilized. Recently diesel powered caterpillar tractors have been built and turned over to the Machine Tractor Stations. These are expected to be turned over to the military. However, this action is expected to be followed by increased use of the remaining tractors, a number of which consume kerosene. Therefore, it appears that no more than about 25,000 tons of POL can be released by agriculture for more essential use.

3. Asiatic Satellites.

It has not been possible, on the basis of presently available information, to distinguish between current military and civilian requirements for petroleum products in the Asiatic Satellites. Based on the estimated requirements for peacetime 1952, it is believed that the over-all yearly requirements for petroleum products in the Asiatic Satellites for peacetime fiscal year 1953 and as follows: aviation gasoline, 110,000 metric tons; other distillate fuels, 400,000 metric tons; residual fuels, 300,000 metric tons; and lubricants, 50,000 metric tons. 10/ These requirements total 860,000 metric tons per year.

It is believed that the petroleum requirements of the Asiatic Satellites will not undergo appreciable change during wartime fiscal year 1954.

No breakdown of the consumption of petroleum products in the Asiatic Satellites by consumer groups has been possible on the basis of presently available information.

Appendix A

POSSIBILITIES FOR CONVERSION OF VEHICLES TO GAS GENERATORS IN THE USSR IN WARTIME FISCAL YEAR 1954

The interest of the USSR in gas generator vehicles has been apparent for some time. During the period immediately preceeding World War II, this interest became most clear. In 1939, a Party Resolution called for the production of a minimum of 80,000 gas generator trucks and tractors during the course of the following three years. 11/ To implement this resolution, the GAZ and ZIS factories were to produce 20,000 gas generator trucks, while the Khar'kov and Chelyabinsk Tractor Plants were to produce 10,000 gas generator tractors during 1939. 12/ The 1941 Plan called for the production of 40,000 gas generator trucks and 10,500 gas generator tractors. There is evidence that previously existing petroleum fueled trucks and tractors were scheduled for conversion to gas generators in this period. Narkomles (People's Commissariat of the Timber Industry) was ordered to convert 2,300 ChTZ-60 tractors and 1,000 trucks to gas generators; Glavlestransprom, 200 tractors and 400 trucks; and TsOLES NKPS, 120 tractors and 400 trucks. 13/

There is very little evidence as to the degree to which these plans were actually carried out. According to one source, about 5 percent of the Soviet truck park was equipped with gas generators before the war; 14/ another source states that about 4 percent of the pre-war agricultural tractor park was gas generator. 15/ It also is believed that a considerable number of trucks and tractors were converted during the course of the war.

In the post-war period, less concrete evidence is available. The Fourth-Five Year Plan called for "guaranteeing a wide application of gas generator.... trucks

in transport, operating on local forms of fuel", and further specified that 70 percent of the trucks and tractors in the Timber Industry should be gas generator types. The recently announced Fifth Five Year Plan calls for the economy "to increase considerably the manufacture of...large gas generator trucks".

The degree to which these plans have been implemented is not clear. It is known that at least one type of gas generator tractor, the KT-12, has been produced by assembly line methods at the Leningrad-Kirov plant, and that at least one type of gas generator trucks, the ZIS-21A, is produced at the UralZIS plant. 16/ In addition it is known that there has been considerable experimentation with gas generators and gas generator equipped trucks and tractors. It is apparent that some of these experiments have been relatively successful; performance data on the experimental GB-58 and GT-58 gas generator tractors have indicated that these models may be roughly equivalent in performance to the S-80 diesel tractor. 17/ It is to be presumed that equally successful experiments have been carried out in the field of gas generator trucks.

There is no evidence, however, that gas generator tractors have to date replaced any substantial portion of the present liquid fueled truck and tractor park, with the possible exception of the vehicles employed in the Timber industry. This would suggest that the present distribution of gas generator trucks and tractors is confined to areas where the timber industry is concentrated: the North and Siberia. It is these areas that the problem of economical hauling of liquid fuels is most acute, and it would, therefore, be anticipated that gas generator equipment would be most useful and economical.

A considerable body of technical information is available on the performance of gas generator equipment, in comparison with similar petroleum fueled equipment. From analysis of this material, it becomes apparent that there are significant economic disadvantages inherent in gas generators.

If engines designed to operate on petroleum fuels are converted to gas generators, a 30 to 40 percent decrease in power can be anticipated. This power loss can be reduced by extensive modification of the engine (increasing the compression ratio, increasing the cylinder capacity, increasing the number of crank-shaft revolutions, increasing the size of the intake and exhaust valves). A diesel or kerosene engine which undergoes these modifications can be expected to deliver equal, or even greater power; in the case of a gasoline engine, a power loss of approximately 10 percent is inevitable. 18/

Load capacity of a converted vehicle is reduced, sometimes as much as 20 percent. 19/

Engine wear is considerably increased, due to the corrosive impurities of the generator gas, and the higher operating speeds necessary to engines operating on gas generators. 20/

The range of vehicles operating on gas generators is severely curtailed; a truck operating on wood can travel only 70 kilometers without refueling, while the optimum range for vehicles operating on other fuels may be said to be 120 kilometers. 21/

Oil and grease consumption of gas generator engines has proved to be higher than the norms for petroleum fueled engines. As an example, there have been reports that the lubricant consumption of the ZIS-21 engine is 200 percent of normal. Modifications can be made to correct this excessive consumption of lubricants. 22/

The labor cost of operating a gas generator engine is higher, both in terms of operating costs, and maintenance costs.

It is apparent from the above that gas generator engines and petroleum-fueled engines converted to gas generators are not without drawbacks. It is believed that it is for these reasons that the Soviet authorities have apparently become less enthusiastic in advocating gas generator vehicles in the postwar period as the solution to the peacetime petroleum fuels problem of their country.

It is also apparent, however, that gas generators have certain favorable characteristics which might make them more attractive in the event of war.

Gas generators may be used to save considerable quantities of strategic petroleum fuels. This is a point of considerable importance.

Gas generators can be operated on a considerable variety of fuels; wood, wood briquettes, charcoal, charcoal briquettes, coke, peat briquettes, and many forms of anal and/or coal cokes. Very few regions of the USSR are without local production of at least one of these forms of solid fuel. This implies that the use of gas generators can greatly decrease the amount of liquid petroleum fuels it is necessary to transport, an important consideration in wartime. In addition, it is apparent that gas generators, if widely used, could meet the minimal motor transport requirements of regions where tactical or strategic considerations make petroleum fuels unavailable. This has important tactical and strategic overtones. However, it is not the function of this paper to investigate these possibilities.

It may, therefore, be that these savings of distillate fuels and transportation would, in wartime, more than offset the incremental investment of materials and labor which would be inherent in the construction, installation, operation and

maintenance of gas generators. An idea of the scale of operation which would be necessary in order appreciably to improve the liquid fuel position of the USSR may be gained from the statement of a Soviet writer in 1939 that "all gas generator machines which are supposed to be produced in 1939 alone will, with good utilization, save more than 200,000 tons of gasoline and kerosene...." 23/ Since 28,000 gas generators were scheduled for production in 1939, it appears that it would be necessary to manufacture and install 140,000 gas generators in order to displace one million tons of distillate fuels a year. The USSR is not believed to be producing generators on anything approximating this scale. However, the generators do not represent a production problem, in terms of steel requirements. The installed weight of current models range from 200 to 800 kilograms, and most of this weight is medium quality rolled steel sheet, steel strips, and steel bands. The generators also require steel pipe, cast iron, and steel forgings. 24/ This quantity of steel should not present a serious obstacle to extensive conversion, even in wartime.

In addition to the metals which would be required for the manufacture of the generator units themselves, it should be pointed out that the internal changes in liquid fuel engines which are necessary to enable them to operate efficiently on gas generators require considerable metal. The nature of these changes has already been touched upon. It is not possible to prepare an estimate of the amount of metal which might be required for these changes.

It must also be pointed out that the building, installation, maintenance, and operation of gas generators would require inputs of skilled and semiskilled manpower which might be difficult to meet in wartime. This would be all the more true if

vast numbers of engines were subjected to extensive overhauls in order to convert them to gas generators.

The solid fuels necessary to operate gas generators are available, in one form or another, in almost every part of the USSR. The flexibility of gas generators with regard to fuels has already been pointed out. The fact that gas generators burn between 200 to 300 percent by weight of the equivalent petroleum fuel, depending on the form of solid fuel which is considered, should not present any substantial obstacle to mass conversion.

In summary, it may be stated that gas generators are not particularly difficult to manufacture. There is evidence that during the last war, gas generators were built by a number of small plants. A simple generator can probably be assembled by a small machine shop. However, in order to obtain conversion in numbers sufficiently large to materially affect the liquid fuel position of the USSR it is believed that it would be necessary to mass produce at least some, and perhaps all, of the major components. This would require plants, organization, and time to tool up and get production under way. It may be expected, therefore, that conversion to gas generators vehicles will not materially effect the fuel position of the USSR during wartime fiscal year 1954.

Appendix B

POSSIBILITIES FOR CONVERSION OF VEHICLES TO COMPRESSED GASEOUS FUELS IN THE USSR IN WARTIME FISCAL 1954

Soviet interest in vehicles operated on compressed gases has paralleled their interest in vehicles operated on gas generators. The first gas cylinder vehicles were operated in the USSR prior to World War II. 25/ In the same period, compressor stations for filling gas cylinders were erected in various parts of the USSR. 26/ It is supposed that the use of vehicles using compressed gas increased somewhat during World War II.

In the postwar period, it is known that the Fourth Five Year Plan called for the wider application of this type of vehicle, together with gas generator vehicles. The Fifth Five Year Plan has as an objective "to expand the use of gas...as an automobile fuel".

The degree to which these postwar plans have been implemented is again not entirely clear. It is known that at least two models of gas-cylinder fueled trucks have been in production: the ZIS-156 and the GAZ-51-B. 27/ Experiments have been conducted in converting other types of trucks to gas generators, but, as far as is known, these converted models are not in production. 28/ In fact, it is believed that even the engines of the GAZ-51 and ZIS-156 are converted from liquid fuel, since a 1951 Soviet source states that "the automobile industry does not yet put out gas cylinder motors". 29/

Very scant information is available on the distribution of compressed-gas vehicles in the USSR. It is known that part of the automobile park in Gorkiy had

been converted to gaseous fuels during the war, and that the resultant savings of gasoline amounted to 10,000 tons per year. 30/ One hundred trucks of Kiev Oblast were converted to gaseous fuels in 1945 and in later years over 500 more trucks were converted. 31/ In 1946, the entire park of the Drogobych oblast were converted, and the same source tells us that many other automobile trusts of the Ministry of Motor Transport of the Ukrainian SSR, including, specifically, the Transcarpathian and Stanislav trusts, were also refitted in the period 1946-1950. 32/ There is also evidence which suggests that gas-cylinder vehicles are in use in other areas of the USSR where gas fuels are conspicuously available: in the areas surrounding petroleum refineries, natural gas fields, and pipelines, and coke ovens. 33/

Liquified gases (usually a mixture of propane and butane) represent the most satisfactory gaseous fuels for motor vehicles. The pressoures at which these gases liquify (2 to 3 atmospheres) make them relatively easy to handle. The compressor stations need not be very large or powerful, and the cylinders which are carried on the vehicles need not be of exceptional weight or strength. The power loss experienced in liquid gasoline engines which are slightly modified to adapt them to the use of gaseous fuels is approximately 4 to 5 percent, which, according to the source, is imperceptible. 34/ If the engine undergoes extensive remodeling (along the same lines required for operation on gas generators), it is possible to secure an increase of power from liquified gas operation of the engine. 35/

Natural gas is a fairly satisfactory fuel, except for the fact that it is compressed to much greater pressure than liquified gas. This involves more complex compressor stations, and requires that the cylinders carried on the trucks be heavier, and of better quality steel. The power loss of an ordinary gasoline engine,

slightly modified to consume gaseous fuel, is approximately 10 to 15 percent, which a Soviet source claims to be "slightly perceptible". 36/ Extensive overhauling and redesign can improve the power characteristics of an engine operating on natural gas.

The least satisfactory gaseous fuel is coke gas or enriched coke gas. Pressures experienced in using these gases appear to be comparable to those experienced when using natural gas. Engine power loss, with only slight modification, is in excess of 20 percent, which a Soviet source states to result in "considerably" lower traction power in the vehicle. 37/ Here again, extensive overhauling can improve performance.

There are difficulties inherent in all vehicles operating on gaseous fuels, in addition to those discussed above.

All vehicles have their carrying capacity reduced somewhat because of the presence of the gas cylinders necessary to carry the fuel gas. The size and number of these cylinders varies both with different models of trucks, and with different kinds of fuel used. For example, the GAZ-51 truck when operating on liquified gas carries a single cylinder made of steel 5 mm thick, 945 mm in length, 400 mm in diameter, and weighing 46 to 50 kg. On the other hand, the ZIS-156, when operating on natural gas, coke gas, or enriched coke gas, carries 8 cylinders of gas, each having a water volume of 50 liters, and a weight of 70 to 75 kg. 34/

The range of vehicles operating on gaseous fuels is curtailed. The degree of curtailment varies, again, with the model of the truck, and with the fuel which is being used. Typical of the upper range of performance is the GAZ-51 operating on liquified gas, which can travel 215 kms. without refueling; representative of the

lower range is the ZIS-156 operating on coke gas, which can travel only 120 kms. 39/

As in the case of gas generator engines, engines operating on gaseous fuels consume 25 to 30 percent more lubricating oil than engines using gasoline. 40/

From the foregoing, it appears that the operation of vehicles on liquified propane or butane is considered to be practical in the USSR, and is a method of substituting gaseous for liquid fuels which does not present any overly complicated technological problems. On the other hand, the substitution of compressed natural gas, or coke gases, for liquid fuels involves increasingly more difficult technological problems, together with greatly diminished operating efficiency.

It would, therefore, seem that in wartime the USSR might be expected to maximize the use of propane or butane fueled vehicles, since these vehicles would involve the smallest investment in steel and manpower per unit of liquid fuel displaced. The limitations which might be expected on the degree of conversion to these fuels would be those imposed by the availability of propane and butane, the availability of compressor station capacity, and the difficulties involved in transporting liquified gas away from compressor stations.

On the first score, the availability of propane and butane, there is very little information, but the USSR is known to be capable of producing considerable quantities of these gases. 41/ It is also believed that present production is well below capacity, in the sense that the maximum recovery is not being made of these gases. 42/ The wartime availability of propane and butane is, therefore, dependent to a large extent on the possibility of increasing the number of stations for the recovery and compression of propane and butane. These stations are not considered to be very difficult to construct, but require inputs of commodities which are

short in wartime. It is, therefore, highly probable that wartime expansion of the number of propane or butane fueled vehicles will be retarded by the difficulties involved in constructing these stations.

Finally, it is highly probable that the use of propane or butane fueled vehicles will continue to be restricted to areas where propane and butane are readily available; that is to say, the immediate vicinity of petroleum refineries, producing fields, and gas pipelines. Though it is true that propane and butane can be transported over long distances in cylinders, or in tank cars of special design, it is also true that the economic justification of liquified gas as a vehicle fuel decreases as the length of the haul increases. It is just as easy, and in many cases easier and cheaper, to transport liquid fuel as to transport gas cylinders back and forth between the source of the gas and the consuming unit. In wartime, this double haul could be very significant.

It is extremely difficult to quantify the amount of liquid fuel which might be saved by incremental conversion of vehicles to propane or butane fuel in the event of war. The evidence which suggests that such conversion would occur, provides no sound basis for quantifying this conversion. As a completely arbitrary figure, it is suggested that conversions which would displace .25 to .50 million metric tons of liquid fuels might be assumed during wartime fiscal year 1954.

With regard to conversions to natural gas, coke gas, or enriched coke gas, the technological problems involved, the larger inputs of steel and manpower, and the major overhauls necessary to the vehicles undergoing conversion, all suggest that there would not be any great number of vehicles converted to these fuels during wartime fiscal year 1954.

Appendix C

SOURCES

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